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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re the Application of: Chakravarthi et al.
Docket No.: TI-33161

Serial No.: 10/020,813
Art Unit: 2813

Filed: 12/12/01
Examiner: Yennhu Huynh

Title: Fabrication of Ultra Shallow Junctions From A Solid Source With Fluorine Implantation

APPEAL BRIEF TRANSMITTAL FORM

MAILING CERTIFICATE UNDER 37 C.F.R. §1.8(a)
I hereby certify that the above correspondence is being deposited with the U.S. Postal Service as First Class Mail in an envelope addressed to: MS AF, Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

Karen Vertz — 6-2-03
Karen Vertz — Date

Commissioner of Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Transmitted herewith in triplicate is an Appellants' Brief in the above-identified application.

The Commissioner is hereby authorized to charge any additional fees for this appeal, or credit any overpayment to Account No. 20-0668. An original and two copies of this Transmittal Form are enclosed.

Respectfully submitted,

Rose Alyssa Keagy
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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re the Application of: Chakravarthi et al. | Docket No.: TI-33161

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Title: Fabrication of Ultra Shallow Junctions From A Solid Source With Fluorine Implantation

APPELLANTS' BRIEF UNDER 37 CFR 1.192

June 2, 2003

MAILING CERTIFICATE UNDER 37 C.F.R. §1.8(A)
I hereby certify that the above correspondence is being deposited with the U.S. Postal Service on 6-2-03 as First Class Mail in an envelope addressed to: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450.

Karen Vertz 6-2-03
Karen Vertz Date

Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450

Dear Sir:

Pursuant to the Notice of Appeal mailed 04/03/03, the Appellants submit this Appellants' Brief in triplicate. The Commissioner is hereby requested and authorized to charge any fees necessary for the filing of the enclosed papers to the deposit account of Texas Instruments Incorporated, Account No. 20-0668.

REAL PARTY IN INTEREST

The real party in interest is Texas Instruments Incorporated, a Delaware corporation.

RELATED APPEALS AND INTERFERENCES

No related appeals or interferences are known to the Appellants.

STATUS OF CLAIMS

Claims 1-7 are the subject of this appeal. Unelected Claims 8-21 are not under appeal.

STATUS OF AMENDMENTS

The Appellants filed an amendment under 37 C.F.R. § 1.116 on March 5, 2003 in response to the final action dated January 14, 2003. In the Advisory Action dated March 25, 2003 the Examiner denied the entry of the amendment.

SUMMARY OF THE INVENTION

Independent Claim 1 and dependent claims 2-7, are described in the Specification from page 4 line 9 to page 8 line 17. Furthermore, Claims I - 7 are described in FIGS. 1 and 2.

Claim 1 is directed to a method of forming a P-N junction within a semiconductor substrate (page 4 line 26). The method involves forming a coating (item 120, step 207, see also page 4 lines 15, 16, 29, and 30 and page 6 lines 22- 23) comprising a dopant (item 122, see also page 4 lines 11) over a surface of the semiconductor substrate (item 110, see also page 4, lines 14 – 15, and page 6 lines 22-23). The semiconductor substrate (110) is heated (step 209, see also page 4 lines 15, 16, and 30, and page 7 line 20) to cause a portion of the dopant (122) to diffuse from the coating (120) into the semiconductor substrate (110, see also page 7 lines 21 - 22); thereby forming a P-N junction (see also page 4 line 26, and page 7 lines 18 - 19).

The semiconductor substrate comprises a single crystal of semiconductor atoms (item 112, see also page 4 line 12). Prior to heating, the single crystal comprises a semiconductor that forms the majority of the crystal (item 110, see page 4 line 12, and page 5 lines 4 - 5) and an impurity atom (item 114, see page 4 line 13, page 5 line 12) that forms a part of the crystal and is distributed primarily within a layer of the crystal adjacent the surface (step 203 and 205, see also page 5 line 20, 21, and 24, and page 6 lines 9-17). The impurity atom has a dose of at least about 1 x 10^{13} atoms/cm^2 within the layer (see page 6 lines 1-2).

The semiconductor substrate has an interstitial form (see page 18 – 22, and page 5 lines 30 - 31). At 1000° C, the impurity atom is a faster diffusing species relative to silicon atoms (see page 4 lines 21 – 24, page 5 lines 29 – 31, and page 7 line 27).

Claim 2 is dependent on Claim 1 and further specifies that prior to heating the impurity atom has a dose of at least about 1×10^{14} atoms/cm^2 within the layer (see page 6 line 4, and also page 6 lines 2 - 3).

Claim 3 is dependent on Claim 1 and further specifies that the impurity atom is fluorine (see page 6 line 1).

Claim 4 is dependent on Claim 1 and further specifies that after heating 90% (see page 7 line 12) of that portion of the dopant that has diffused into the semiconductor substrate is located within about 50 nm from the surface of the semiconductor substrate (see page 8 line 4).

Claim 5 is dependent on Claim 1 and further specifies that the dopant is boron (see page 7 lines 14 - 15).

Claim 6 is dependent on Claim 1 and further specifies that after heating the concentration of the dopant within the substrate adjacent the surface is at least about 1×10^{19} atom/cm^3 (see page 8 line 6)

Claim 7 is dependent on Claim 1 and further specifies that the coating comprises a silicate glass (page 6 lines 25 – 27).

ISSUES

1. Whether Claims 1 - 7 are unpatentable under 35 U.S.C. §103(a) over Lee (U.S. Pat. No. 5,773,337) in view of Lee (U.S. Pat. No 6,037,640).

GROUPING OF CLAIMS

Claims 1 - 7 stand separately.

ARGUMENT

Issue 1- Whether Claims 1 - 7 are unpatentable under 35 U.S.C. §103(a) over Lee (U.S. Pat. No. 5,773,337) in view of Lee (U.S. Pat. No 6,037,640).

Claim 1 positively recites the step of forming a coating comprising a dopant over a surface of the semiconductor substrate. In addition, Claim 1 positively recites the step of heating the semiconductor substrate to cause a portion of the dopant to diffuse from the coating into the semiconductor substrate. There is no teaching of these advantageously claimed steps in Lee ('337) or Lee ('640), either alone or in combination.

The Appellants respectfully traverse the Office Action statement that Lee ('337) discloses 'forming a coating comprising a dopant over a surface of the semiconductor substrate.' As noted by the Appellants in the 111 Amendment, the 'coating' described by

Lee ('337) at the location stated in the Office Action is "photoresist film" (column 2 lines 48, 52, and 54) and not the Appellants' "coating comprising a dopant." The use of the Lee ('337) 'coating' teaches away from the advantageously claimed invention because the photoresist coating taught by Lee ('337) does not contain dopants and dopants don't diffuse from the photoresist coating into the semiconductor substrate as advantageously claimed.

Furthermore (as also mentioned in the Appellants 111), Lee ('337) teaches that the dopants are implanted (column 2 lines 49, 55, and 61) into the semiconductor substrate. Therefore Lee ('337) teaches away from the advantageously claimed step of causing the dopants to diffuse from the coating into the semiconductor substrate.

The Appellants agree with the statement in the Office Action that Lee ('337) does not disclose an impurity dosage of $1x10^{13}$ atoms/cm^2, as advantageously claimed.

Moreover, Claim 1 teaches that the semiconductor substrate comprises a single crystal and an impurity atom forms a part of the crystal. Lee ('337) does not teach that the semiconductor substrate is a single crystal (as acknowledged in the Office Action). Lee ('337) also does not teach the use of an impurity atom as advantageously claimed.

Lee ('337) further teaches away from the advantageously claimed invention because Lee ('337) teaches the use of a BPSG coating as an insulating film at a location separated from the source and drain. The Appellants submit that Lee ('337) does not teach the use of the BPSG coating for active junction formation. Contrary to Lee ('337),

the Appellants teach the use of a BPSG coating as a source for the dopants at a location adjacent to the source and drain (FIG. 1 and page 6 line 27).

Again, Claim 1 positively recites the step of forming a coating comprising a dopant over a surface of the semiconductor substrate. In addition, Claim 1 positively recites the step of heating the semiconductor substrate to cause a portion of the dopant to diffuse from the coating into the semiconductor substrate.

As the Appellants stated in their 111 Amendment, Lee ('640) teaches away from the advantageously claimed invention because Lee ('640) also teaches that the dopant is implanted using the ion implantation technique (column 3 line 43 and column 6 lines 35-38), rather than diffusing the dopant from a coating containing a dopant as advantageously claimed.

The Appellants respectfully traverse the assertion in the Office Action that Lee ('640) teaches that "the semiconductor substrate comprises a single crystal." The Office Action points to verbiage in the 'Background of the Invention' section to support that assertion. The Office Action does not support that assertion by pointing to any statements in the 'Summary of the Invention' or the 'Detailed Description of the Invention' sections.

In addition, the Appellants respectfully traverse the assertion in the Office Action that Lee ('640) teaches a specific dose of an impurity ion and that the impurity ion is fluorine. The dosage verbiage that the Office Action points to (column 7 lines 27-30)

concerns a preamorphization step (column 7 line 23); therefore, it is not a teaching concerning an impurity ion dosage (as asserted in the Office Action). In addition, the Office Action points to verbiage in the 'Background of the Invention' section to assert that Lee ('640) teaches the use of fluorine as the impurity atom. Lee ('640) does not teach the use fluorine as an impurity atom, in fact Lee ('640) does not teach the use of any impurity ion. Rather Lee ('640) teaches the implantation of ions (not impurity ions) only for preamorphization (column 6 lines 1-9 and 26-27; and column 7 lines 14-22) or dopant implantation (column 6 lines 35-38). Moreover, Lee ('640) teaches away from the advantageously claimed invention because in the 'Background of the Invention' Lee states that the use of "fluorine co-implants...inhibits the formation of ultra-shallow junctions."

The Appellants respectfully traverse the declaration in the Office Action that it "would have been obvious to one having ordinary skill in the art at the time of the invention was made to modify the invention of lee ('337) by incorporating an ion dosage of about $1x10^{13}$ atoms/cm^2, to avoid short channel effects in forming shallow junctions." The Appellants submit that this assertion is illogical because the Appellants teach the use of an impurity atom and impurity atoms cannot help with short channel effects.

Moreover, even if the teachings of Lee ('337) and Lee ('640) were combined, the combination does not teach or suggest the advantageously claimed elements; for example, the diffusion of the dopant from the coating into the semiconductor substrate and the use of impurity atoms (as explained in detail supra).

Therefore, Claim 1 is patentable over Lee ('337) and Lee ('640), either alone or in combination.

Claim 2 is dependent on Claim 1 and is therefore allowable for the same reasons that Claim 1 is allowable. Furthermore, Claim 2 is allowable on its own merits because it recites additional features of the invention that are not taught nor suggested by the applied references. Claim 2 further specifies that prior to heating the impurity atom has a dose of at least about 1×10^{14} atoms/cm^2 within the layer. This combination is not suggested in the references. There is no teaching or suggestion in Lee ('337) or Lee ('640) of the use of an impurity atom - much less any dosage of an impurity atom.

Claim 3 is dependent on Claim 1 and is therefore allowable for the same reasons that Claim 1 is allowable. Furthermore, Claim 3 is allowable on its own merits because it recites additional features of the invention that are not taught nor suggested by the applied references. Claim 3 further specifies that the impurity atom is fluorine. This combination is not suggested in the references. There is no teaching or suggestion in Lee ('337) or Lee ('640) of the use of an impurity atom - much less a fluorine impurity atom. In fact, as stated supra, Lee ('640) states in the Background section that the use of fluorine impurity atoms is undesirable.

Claim 4 is dependent on Claim 1 and is therefore allowable for the same reasons that Claim 1 is allowable. Furthermore, Claim 4 is allowable on its own merits because it recites additional features of the invention that are not taught nor suggested by the applied references. Claim 4 further specifies that after heating 90% of that portion of the dopant that has diffused into the semiconductor substrate is located within about 50 nm

from the surface of the semiconductor substrate. This combination is not suggested in the references. There is no teaching or suggestion in Lee ('337) or Lee ('640) concerning the equilibrium value at various saturation levels - much less the specific saturation level of 90%.

Claim 5 is dependent on Claim 1 and is therefore allowable for the same reasons that Claim 1 is allowable. Furthermore, Claim 5 is allowable on its own merits because it recites additional features of the invention that are not taught nor suggested by the applied references. Claim 5 further specifies that the dopant is boron. This combination is not suggested in the references. Specifically, neither Lee ('337) nor Lee ('640) teach or suggest this further limitation in combination with the other requirements of Claim 1.

Claim 6 is dependent on Claim 1 and is therefore allowable for the same reasons that Claim 1 is allowable. Furthermore, Claim 6 is allowable on its own merits because it recites additional features of the invention that are not taught nor suggested by the applied references. Claim 6 further specifies that after heating the concentration of the dopant within the substrate adjacent the surface is at least about $1x10^{19}$ atom/cm^3. This combination is not suggested in the references. There is no teaching or suggestion in Lee ('337) or Lee ('640) of a dopant concentration of $1x10^{19}$ atom/cm^3 adjacent the substrate surface.

Claim 7 is dependent on Claim 1 and is therefore allowable for the same reasons that Claim 1 is allowable. Furthermore, Claim 7 is allowable on its own merits because it recites additional features of the invention that are not taught nor suggested by the applied references. Claim 7 further specifies that the coating comprises a silicate glass.

This combination is not suggested in the references. Neither Lee ('337) nor Lee ('640) teach or suggest this further limitation in combination with the other requirements of Claim 1. More specifically, there is no teaching or suggestion in Lee ('337) or Lee ('640) of the use of a coating of silicate glass adjacent to the surface of the semiconductor substrate.

The Appellants respectfully traverse the assertion in the Office Action that it "would have been obvious to one having ordinary skill in the art at the time of the invention was made to modify the invention of Lee ('337) by incorporating an impurity ion dosage at about $1x10^{14}$ atoms/cm^2; a diffused region is [sic] located about 50nm from the surface; dopant concentration is [sic] at about $1x10^{18}$ atoms/cm^2, to obtain an abrupt change in the slope of the dopant profile at the shallow junctions." The Appellants submit that the abruptness of the junction is defined by the nature of the diffusivity of boron in silicon. Therefore, current technologies are all limited by this maximum slope (ranging from 5 - 10 nm/dec). However, the use of the advantageously claimed fast diffusing species like fluorine provides a means to go beyond this limit. Thus the Appellants' invention achieves an abruptness that is much better than what is possible through the teachings of Lee ('337) or Lee ('640) because neither patent teaches the use of impurity atoms, such as fluorine, as advantageously claimed.

CONCLUSION

For the reasons stated above, the Appellants respectfully contend that each claim is patentable. Therefore, the reversal of all rejections is courteously solicited.

Respectfully submitted,

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APPENDIX

Claims on Appeal

1. A method of forming a P-N junction within a semiconductor substrate, comprising:

forming a coating comprising a dopant over a surface of the semiconductor substrate; and

heating the semiconductor substrate to cause a portion of the dopant to diffuse from the coating into the semiconductor substrate and thereby form a P-N junction within the semiconductor substrate;

wherein the semiconductor substrate comprises a single crystal;

prior to heating, the single crystal comprises a semiconductor that forms the majority of the crystal and an impurity atom that forms a part of the crystal and is distributed primarily within a layer of the crystal adjacent the surface;

the impurity atom has a dose of at least about 1×10^{13} atoms/cm^2 within the layer;

the semiconductor has an interstitial form; and

at 1000° C, the impurity atom is a faster diffusing species relative to silicon atoms.

2. The method of claim 1, wherein prior to heating, the impurity atom has a dose of at least about 1×10^{14} atoms/cm^2 within the layer.

3. The method of claim 1, wherein the impurity atom is fluorine.

4. The method of claim 1, wherein after heating 90% of that portion of the dopant that has diffused into the semiconductor substrate is located within about 50nm from the surface of the semiconductor substrate.

5. The method of claim 1, wherein the dopant is boron.

6. The method of claim 1, where after heating the concentration of the dopant within the substrate adjacent the surface is at least about $1x10^{19}$ atom/cm^3.

7. The method of claim 1, wherein the coating comprises a silicate glass.